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The Effect of GDP per Capita, Corruption Perception Index, Human Development Index, and Coal Consumption on Carbon Dioxide Emissions in the BRICS Group of Countries

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Abstract

Economic growth is an important indicator for a country's economy. Along with the development of economic activity, it also has an impact on the environment. This is discussed in the Environmental Kuznets Curve (EKC) theory where when per capita income increases, at a certain income level, environmental degradation also decreases. This study uses the Pooled Mean group/ARDL method from 1996 to 2021 in the BRICS country group. The results show that the EKC hypothesis does not hold in the short term, but holds in the long term. The corruption perception index has a positive and insignificant effect in the short term and a positive and significant effect in the long term, the human development index has a negative and insignificant effect in the short term and a negative and significant effect in the long term, finally coal consumption has a positive and significant effect in the short term and in the long term. Suggestions in this study include optimizing carbon taxes for countries that have not implemented them and making industrial business feasibility tests so that there are restrictions related to the waste produced.

Keywords: EKC, Carbon Emissions, Corruption Perseption Index, Human Development Index, Coal Consumption, Pooled Mean Group

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INTRODUCTION

Economic growth is an important key for every country to prosper. Yogatama, (2022) explains that increasing economic growth can accelerate development in a country. Every country will certainly experience changes in economic transition that require assistance or cooperation from other countries. BRICS is one example of a group of countries that decided to cooperate with the aim of strengthening relations between members in various fields including economic, trade, financial, political, and social.

As economic activity develops, it also affects environmental conditions, especially in increasing carbon emissions. Arifah, (2023) explains that carbon dioxide emissions as one of the residues of industrial activities have an impact on increasing greenhouse gases to environmental degradation.

According to National Geographic, human activity has a significant contribution to increasing carbon dioxide emissions. Then based on the United States Environmental Protection Agency (EPA) statement in 2021, said from 1990 to 2015 carbon emissions increased by 51% and accounted for about three-quarters of total global emissions. In 2022, carbon dioxide emissions increased by 1.5% compared to 2021 (Liu, et al. 2023). According to Carbon Brief, historically all BRICS members have been among the top 20 emitters globally, with China second, Russia third, Brazil fourth, India seventh and South Africa 16th. Russia contributes about 7% of cumulative carbon dioxide emissions.

Increased CO_2 emissions in the earth's atmosphere cause global warming which then increases the earth's temperature, this will certainly have a negative impact on the life of the earth (Kristiadi et al. 2020). Increased carbon emissions lead to hotter global temperatures, weather changes, and human health. Countries around the world are moving in ambition to reduce carbon emissions in ways such as increasing the use of electric cars, energy storage, and the use of renewable energy.

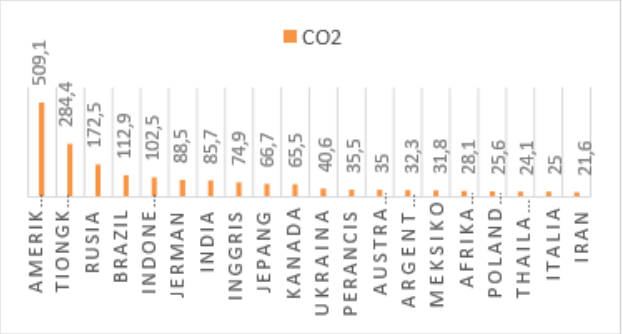

Figure 1. Ranking of Carbon Emitters 1850-2021 ($GtCO_2$)
Source: Carbon Brief, data processed 2023

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Countries around the world are moving in ambition to reduce carbon emissions in ways such as increasing the use of electric cars, energy storage, and the use of renewable energy. According to the Reserve Bank of India (2021), BRICS is a group of countries that represent 41% of the world's population, 24% of global GDP, and 16% of world trade. Increased CO_2 emissions in the earth's atmosphere cause global warming which then increases the earth's temperature, this will certainly have a negative impact on the life of the earth (Kristiadi et al. 2020).

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The level of corruption is one of the important discussions in a country because it has a destructive and widespread impact on various aspects of the economy. The impact of corruption is also a problem that can hinder economic development in a country. The level of corruption in a country can be measured through the Corruption Perceptions Index (CPI) reported by Transparency International.

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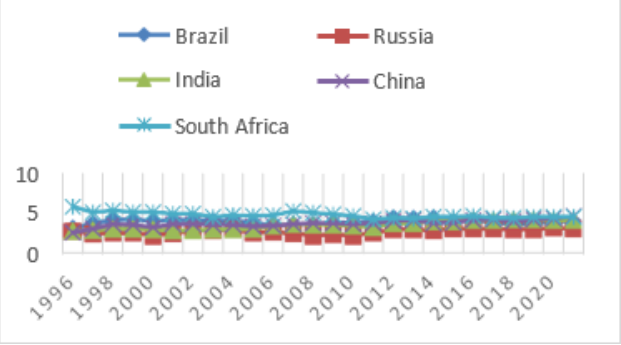

Figure 2. BRICS Corruption Perception Index 1996-2021 (Index Point)
Source: Transparency International, data processed 2023

According to the United Nations Educational, Scientific, and Cultural Organization (UNESCO), the development of a country can not only be measured through economic growth but there is an emphasis that humans and their abilities must be the main criteria. To measure or analyze the level of human social and economic development in a country or region requires the Human Development Index (HDI) as an indicator. HDI itself is calculated from several aspects of development including education, health, and income.

Bano, et al. (2018) Carbon emissions can be reduced in improving human quality, with good human development will produce a workforce that is skilled, innovative, productive and more understanding of environmental sustainability. Eric, et al. (2022) examined the relationship between HDI and environmental sustainability with the result that an increase in HDI can lead to better environmental sustainability through reduced ecological footprint, carbon dioxide emissions, greenhouse gases, and exposure to airborne populations.

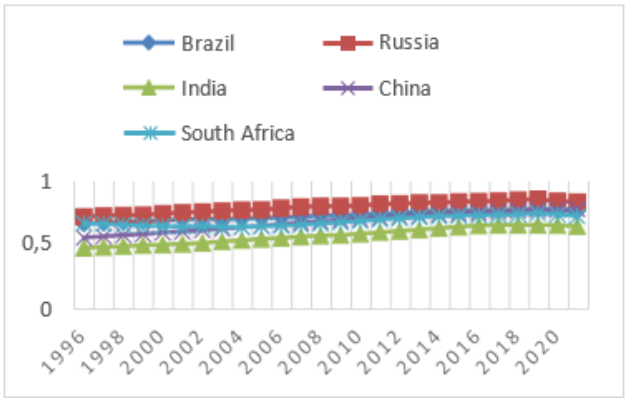

Figure 3. BRICS Human Development Index 1996-2021 (Index Point)
Source: Our World in Data, data processed 2023

Furthermore, the increase in carbon emissions can also be influenced by coal consumption. Coal is one of the fossil fuels formed by organic compounds naturally

Setiawan, et al. (2020). Based on the International Energy Agency (IEA) report, (2023) carbon dioxide emissions from fossil fuels are dominated by coal by 44%, while other fossil fuels are lower, namely petroleum by 35% and natural gas by 20%.

According to research by Setiawan, et al. (2018) that combustion that occurs in coal can produce a number of emissions that have a negative impact on the environment such as CO, CO2, NOx, and SOxOf course this can lead to depletion of the earth's ozone layer which has an impact on human health.

According to the client earth report, (2022) says that coal is a fossil fuel, and is the dirtiest fuel and is responsible for an increase of 0.3°C of the global average temperature increase of 1°C. This makes it the single largest source of global temperature rise. This makes it the single largest source of global temperature rise. The relationship between income and environmental degradation is explained in the Kuznets hypothesis in the Environmental Kuznets Curve (EKC) theory.

Based on research conducted by Adeel-Farooq (2020) states that the results of testing the EKC theory in selected ASEAN countries (Indonesia, Malaysia, Philippines, Singapore, Thailand and Vietnam) show valid evidence. In lower MiddleIncome countries where they are still in the early stages of development so that the EKC hypothesis has not occurred in these countries.

Furthermore, Tuna, et al. (2022) proved the existence of the EKC hypothesis in countries in East Asia and Asia Pacific in 1971-2016. Then Genç, et al. (2021) found the existence of EKC in Turkey in 1980-2015. On the other hand, Chng (2019) examined the existence of EKC in 1971-2013 in Singapore, Thailand, and Vietnam.

Then in Malaysia, the Philippines, and Indonesia, the existence of EKC was not found. Then in the research of Rahman, et al. (2022) said that the EKC hypothesis was found in the long term, but was not significant in the short term in the top 10 tourist countries from 1972 to 2021.

With this, the author is interested in testing the Environmental Kuznets Curve and the effect of GDP per capita, corruption perception index, human development index, and coal consumption on carbon dioxide emissions because environmental issues are one of the hot issues being discussed at various international meetings.

The Environmental Kuznets Curve (EKC) is a concept that explains the relationship between a country's income level and environmental degradation. Kuznets (1955) in his article entitled "Economic Growth and Income Inequality" explains the relationship between economic growth and income inequality in a country. This study shows that income inequality will change along with economic growth and the change will form an inverted U curve.

Grossman and Krueger (1994) applied Kuznets' hypothesis in their article entitled "Economic Growth and the Environment" which examined the relationship between the scale of economic activity and environmental quality.

Using the variables of urban air pollution concentrations, measures of oxygen regime conditions in watersheds, fecal contaminant concentrations in watersheds, and river flow concentrations as variables that serve as environmental indicators and show the existence of an inverted U curve between income per capita. The results explain that if the increase in per capita income up to a certain point, it will reduce the level of environmental

degradation. This is due to public awareness to improve environmental conditions.

An externality in economics is an impact of economic activity that is felt by third parties who are not involved in the activity. Global warming is an example of a large-scale externality and according to economists, global warming caused by fossil fuels is one of the classic examples of the concept of externalities. Externalities occur because the actions of one party make another party worse or better off, but the first party does not participate in bearing the costs or receiving the benefits of the action (Gruber, 2016).

RESEARCH METHODS

This type of research is quantitative research from 1996 to 2021 in Brazil, Russia, India, China, and South Africa. Quantitative research method is a method used to answer research problems related to data in the form of numbers and statistical programs (Wahidmurni, 2017).

On this occasion, researchers tested a theory by formulating the right hypothesis. The data that is then collected is then processed to support or refute the hypothesis that has been presented. The data collected by researchers is secondary data sourced from the World Bank, Our World in Data, British Petroleum, and transparency perception. Furthermore, the data is processed using the Pooled Mean Group/Autoregressive Distributed Lag (ARDL) research method.

The nature of this research is associative research. Associative research is research that aims to determine the relationship or correlation between two or more variables. On this occasion, researchers used variables such as carbon dioxide emissions as dependent variable, GDP per capita, corruption perception index, human development index, and coal consumption as independent variable.

This study uses data on total carbon dioxide emissions per capita in tons per capita from 1996 to 2021. This is the total annual production-based carbon dioxide (CO_2) emissions measured in tons per person and based on territorial emissions. This study uses GDP per capita data in thousands of USD from 1996 to 2021. Gross Domestic Product (GDP) per capita is GDP divided by the mid-year population.

This study uses the Corruption Perspective Index (CPI) or corruption perception index in units from 1996 to 2021. The CPI is a composite indicator to measure perceptions of public sector corruption on a scale of 0 to 100 across 180 countries and territories based on a combination of 13 global surveys and assessments of corruption according to business perceptions and expert assessments worldwide since 1995.

This research uses the Human Development Index (HDI) in units from 1996 to 2021. The HDI is a summary measure of achievement in the three main dimensions of human development, namely a long and healthy life, access to knowledge, and a decent standard of living.

This study uses coal consumption in exajoules from 1996 to 2021. This coal consumption is only commercial solid fuels, namely bituminous and anthracite coal, as well as lignite and brown coal, and other commercial solid fuels. It excludes coal converted to liquid fuel or gas, but includes coal consumed in the transformation process.

The techniques used in collecting data for this study are documentation and literature study. Documentation is a data collection

method related to the use and recording of information from written sources. In this research, the documentation method is used to access and record data that has been officially published by the World Bank, Transparency, British Petroleum, and Our World in Data, as well as news pages related to this research.

Literature study is a method of collecting data by exploring and searching for literature that is relevant to the research problem being studied and includes a series of activities that include searching, reading, researching, and processing information from various literature sources. In this study, researchers searched, researched and quoted literature such as books, scientific journals, and research reports that had been carried out previously and had a connection with the research topic being carried out.

In this study, after collecting data, researchers conducted a data analysis stage. This analysis is carried out to answer the problems presented. Researchers used the Pooled Mean Group / Autoregressive Distributed Lag (ARDL) analysis method. This method was first discovered by Pesaran and Shin in 1997 to estimate long-term and short-term coefficients on variables.

This method is done to overcome regression models that have different levels of stationarity. One of them is that it can be used on short series data and does not require preestimation classification of variables. Thus, this method can be used at stationary level I(0), I(1), or a combination of both (Ekananda, 2018).

RESULTS AND DISCUSSION

The results showed the existence of EKC in the BRICS group of countries in the long run. The results of this study are supported by research by Alfiansyah, et al (2022) which shows the results if the formation of an inverted U curve or EKC hypothesis is proven in the long run but not in the short run. Then it is also in line with the research of Akadırı, et al. in 2021 which shows the results if the existence of the EKC hypothesis is only proven in the long run.

However, the results of this study contradict the research of Ben, et al. (2022) which says that the EKC hypothesis is not proven. Then, according to a report by the International Labor Organization in 2022, all BRICS members will have made their Nationally Determined Contribution (NDC), which is at the core of the Paris Agreement with the aim of reducing national emissions and adapting to the impacts of climate change.

Brazil and Russia's NDCs were submitted in 2020, China's and South Africa's in 2021, and Russia's from 2021. All countries have committed to a zero-emission target with Russia, Brazil and China targeting 2060, India 2070 and South Africa 2050.

Corruption is an act of abuse of official position by public or state officials for personal gain. Cahyono, et al. (2015) said that eradicating corruption can lead to an increase in the activity of economic sectors which further increases the resulting carbon emissions as a cause of climate change.

Furthermore, Akhbari and Nejati, (2019) explained that the corruption variable has a negative influence on carbon emissions. Every increase in the corruption index will decrease carbon emissions by 0.08 index point. On the other hand, according to research by Cahyono, et al. (2015) shows that the corruption perception index variable has a positive influence on carbon dioxide emissions.

Table 1. Short-term Pooled Mean Group ARDL Model Estimation Results

Variable		Coefficient	Std. Error	t- Statistic	Prob.
Name	Notation				
ECM Coefficient	COIN TEQ01	- 0.540927	0.244034	- 2.216603	0.0302
GDP per Capita	D(YCA P)	0.243235	0.158153	1.537966	0.1289
GDP per Capita 1 Period Prior	D(YCA P(-1))	0.017112	0.070363	0.243193	0.8086
GDP per Capita Quadratic	D(YCA P2)	- 0.009914	0.012382	- 0.800679	0.4262
GDP per Capita Quadratic 1 Previous Period	D(YCA P2(-1))	0.012853	0.011676	1.100849	0.2750
Corruption Perception Index	D(CPI)	0.006596	0.074445	0.088607	0.9297
Corruption Perception Index 1 Previous Period	D(CPI(-1))	-0.065884	0.031737	- 2.075970	0.0419
Human Development Index (HDI)	D(HDI)	- 8.360688	10.46928	- 0.798593	0.4274
HDI 1 Previous Period	D(HDI(-1))	- 13.47418	11.76659	- 1.145122	0.2564
Coal Consumption	D(COAL)	0.815297	0.366734	2.223129	0.0297
Coal Consumption 1 Previous Period	D(COAL(-1))	- 0.004956	0.111427	- 0.044474	0.9647
Constant	C	3.673085	2.750742	1.335307	0.1864

Source: Data processed, 2023.

In Figure 4, it can be seen that the CPI trend in the BRICS country group has increased from 1996 to 2021. This indicates that if the CPI value increases then in that year there is a decrease in the number of corruption. The positive effect of the corruption perception index on carbon emissions in this study is thought to be because strengthening corruption institutions will facilitate the country's economy through the allocation of funds provided for accelerated development, including strengthening the industrial sector which is one of the carbon dioxide producing factors. The increasing CPI trend in the BRICS group of countries also resulted in an increase in the trend of foreign direct investment into the BRICS group of countries due to an increase in the level of confidence of foreign investors.

This can be seen in figure 5, illustrating the increasing trend in the amount of foreign direct investment from 1996 to 2021. This increase in foreign direct investment affects funding in various sectors including the industrial sector. The funding drives the industry so that it continues to increase until this year.

According to the BRICS Joint Statistical Publication in 2022 reported that from 2012 to 2021 there was an increase of about 74% in the average production of the petroleum industry in BRICS with Russia dominating or being the highest ranked in the petroleum production industry. From 2012 to 2021 there was an increase of 205% in the average production of the electricity industry in BRICS with China having the highest rate of electricity production. Based on the results of the long-term balance in the

Pooled Mean Group estimation, it can be concluded that the human development index has a negative and significant effect on the amount of carbon dioxide emissions per capita.

Table 2. Estimation Results of Long-Term Pooled Mean Group ARDL Model

Variable		Coefficient	Std. Error	t- Statistic	Prob
Name	Notation				
GDP per Capita	YCAP	0.284722	0.030891	9.216888	0.0000
GDP per Capita Quadratic	YCAP2	-0.010023	0.001668	-6.008246	0.0000
Corruption Perception Index	CPI	0.375662	0.105557	3.558862	0.0007
Human Development Index	HDI	-3.164274	1.127484	-2.806490	0.0066
Coal Consumption	Coal	0.054002	0.002512	21.49998	0.0000

Source: Data processed, 2023.

This research is supported by Saqib, et al. (2022) explained the negative effect of the human development index on carbon emissions. A high human development index will increase awareness of the negative impact of carbon dioxide emissions that exacerbate global temperatures.

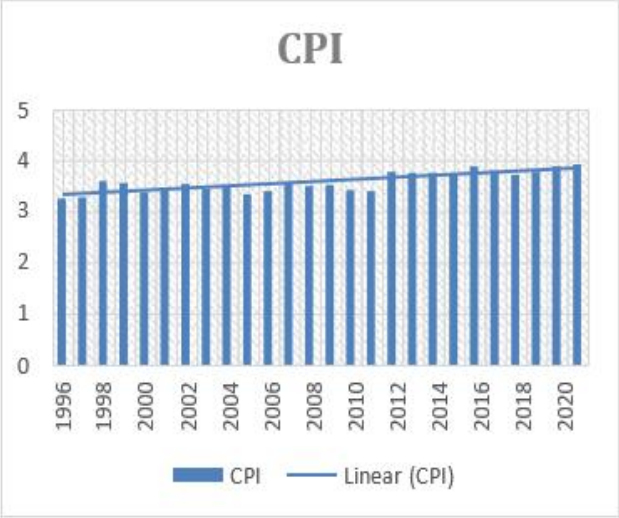

Figure 4. BRICS CPI Trends 1996-2021 (Index Point)
Source: Transparency.org, data processed 2023

This awareness will lead to human nature that is more friendly to the environment and environmentally friendly policies to reduce carbon dioxide emissions. This research contradicts Bieth in 2021 who found a positive but insignificant relationship between the human development index and carbon emissions.

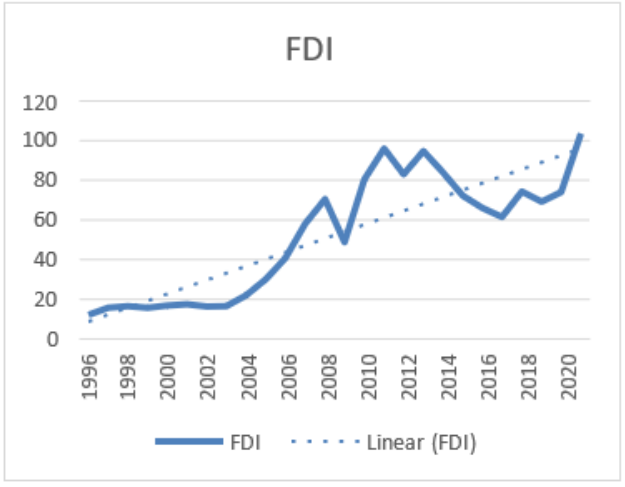

Figure 5. BRICS FDI Trends 1996-2021 (Index Point)
Source: World Bank, data processed 2023

If HDI increases by 1% per year, it will increase CO_2 emissions by 7.62%. This happens because countries with high HDI numbers will fulfill high consumption, thus releasing carbon emissions. The results of the HDI variable in this

study have a negative effect on carbon dioxide emissions.

This is thought to be because people with high HDI have great awareness in protecting the environment. This awareness certainly encourages the government to create policies that are friendly to the environment to reduce carbon dioxide emissions. According to the joint statement issued at the BRICS high-level meeting on climate change in 2022 reported that China has proposed initiatives to reduce carbon dioxide emissions.

Based on the results of this study, coal consumption has a positive and significant influence. The results of this study are supported by Sa'dah, et al. (2019) which shows that coal consumption has a positive and significant effect on carbon dioxide emissions. When coal consumption increases every 1 mtoe (million tons oil equivalent), carbon dioxide emissions in Indonesia will increase by 2.979 million tons. Furthermore, Dingru , et al. (2021) concluded that a 1% increase in coal consumption will increase environmental degradation by 1.077%.

This happens because coal is burned to produce energy, such as electricity or heat, the combustion process produces CO_2 emissions. The results of this study are also in line with research conducted by Wijaya (2017) which found that coal consumption has a positive relationship with CO_2. The positive results of this study are thought to be due to one of the fossil fuels that most contribute to the increase in carbon dioxide emissions.

BRICS is considered to still have dependence on fossil energy, this is evidenced by the BRICS Energy Research Coorporation Platfrom report (2020) saying that fossil fuels will continue to dominate BRICS countries until 2040. Furthermore, according to Peng and Liu (2022), carbon emissions from coal consumption in China increased by 3211.92 million tons from 1997 to 2019.

CONCLUSION

Based on the results of research that has been conducted on "The Effect of GDP per Capita, Corruption Perception Index, Human Development Index, and Coal Consumption on Carbon Dioxide Emissions in the BRICS Group of Countries" it can be concluded that the Environmental Kuznets Curve (EKC) hypothesis is not proven in the short term, but it is proven in the long term.

This is because it takes a long time to see a decrease in carbon dioxide emissions. The proof of EKC is allegedly because BRICS member countries have made efforts to improve environmental quality, including reducing the level of carbon dioxide emissions.

Russia is a BRICS country that has reached the turning point and the other four countries have not yet reached the turning point. The corruption perception index has a positive and significant effect in the long run because a decrease in the level of corruption can indirectly encourage economic growth, causing an increase in carbon dioxide emissions. The Human Development Index (HDI) has a negative and significant effect in the long run.

This is expected because with the increase in HDI, the quality of public awareness of environmental damage also increases, resulting in a decrease in carbon dioxide emissions. Coal consumption has a positive and significant effect in the long run. This is because an increase in coal consumption will increase combustion which can produce a lot of carbon dioxide emissions.

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